Ontario Geological Survey

Aggregate Resources Inventory Paper 14

AGGREGATE RESOURCES INVENTORY OF TOWNSHIP OF NORTH DUMFRIES REGIONAL MUNICIPALITY OF WATERLOO SOUTHERN ONTARIO

by

Staff of the Engineering and Terrain Geology Section

Ontario Geological Survey

1980

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Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Natural Resources does not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

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ABSTRACT

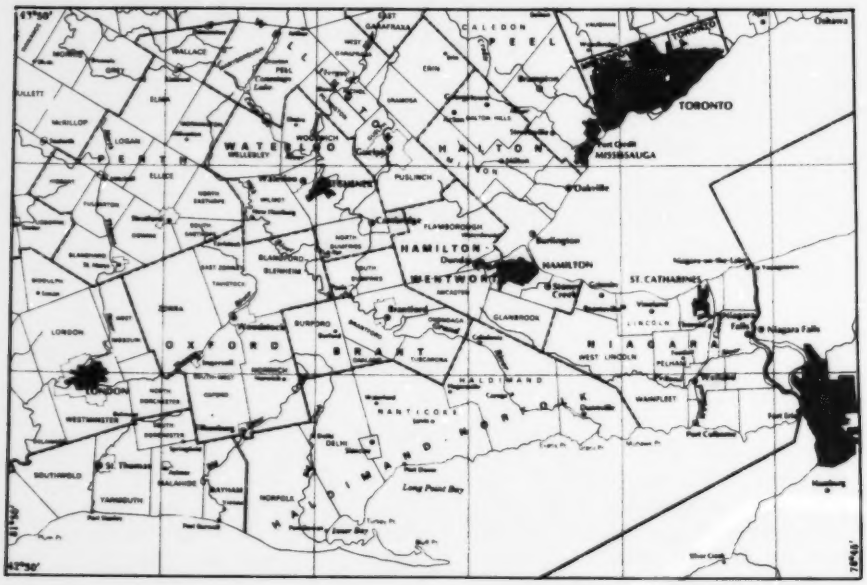

Figure 1. Key Map Showing Location of The Township of North Dumfries. Scale 1:1 800 000.

This report includes both an inventory and evaluation of sand and gravel as well as bedrock resources in the Township of North Dumfries. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under The Pits and Quarries Control Act, 1971.

In the Township of North Dumfries, six areas containing significant amounts of sand and gravel have been selected for possible resource protection. Selected Sand and Gravel Resource Areas occupy 11,100 acres (4500 ha), exclusive of licenced areas. An estimated 9400 acres (3800 ha) are currently available for extraction, containing possible resources of approximately 470 million tons (425 million tonnes). The parts of the Selected Areas which are available for extraction represent 37 percent of the total area occupied by sand and gravel in the township and 41 percent of the total resource tonnage.

Selected Sand and Gravel Resource Area 1, an outwash deposit near the City of Cambridge, is the most important natural aggregate source in the township. The deposit contains an estimated 95 million tons (86 million tonnes) of sand and gravel suitable for a full range of crushed products, including concrete aggregate.

Selected Sand and Gravel Resource Area 2, an outwash deposit located along the east side of Cedar Creek, contains an estimated 105 million tons (95 million tonnes) of material suitable for a range of aggregate products.

Selected Sand and Gravel Resource Area 3 is located along the west side of Cedar Creek. Area 3 has available resources of approximately 140 million tons (127 million tonnes) of sandy gravel.

Selected Sand and Gravel Resource Area 4 is a buried outwash deposit located to the north of Area 3. Area 4 has an estimated sand and gravel reserve of 10 million tons (9 million tonnes). The material is acceptable for a range of granular base course and hot-laid asphaltic products.

Selected Sand and Gravel Resource Area 5 is an outwash deposit located on the west bank of the Grand River. The Area contains an estimated 110 million tons (100 million tonnes) of aggregate suitable for road-base, sub-base, and hot-laid asphaltic uses.

Selected Sand and Gravel Resource Area 6 is a small, sandy outwash deposit located to the east of the Grand River. Resources are estimated to be 8 million tons (7 million tonnes) of material acceptable for granular base course and hot-laid asphaltic products.

Generally, the Township of North Dumfries has possible sand and gravel resources which are important regional sources of road-building and construction material. Care should be taken to ensure the continuing availability of as much of these resources as possible.

The Township of North Dumfries is underlain by bedrock of the Salina and Guelph Formations. Neither formation is well suited for the production of road-building or construction aggregates. The Guelph Formation is, however, suitable for the manufacture of lime. Two areas in the eastern portion of the township have been selected for possible protection, containing a total estimated resource of 430 million tons (390 million tonnes).

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY OF TOWNSHIP OF NORTH DUMFRIES[1]

BY
STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1976, the total tonnage of mineral aggregates extracted was greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1977).

Although mineral aggregate deposits are plentiful in southern Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the reports. As new information becomes available, revisions may be necessary.

[1] Manuscript accepted for publication by Chief, Engineering and Terrain Geology Section, June 6, 1980.

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PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References). Wherever possible, field examination of potential resource areas was also undertaken to confirm interpretations made in the office. Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-size fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Air photos at various scales were used to determine the continuity of deposits, especially in areas of limited subsurface information.

In the office, the pit data were supplemented by information on file with the Engineering Materials Office of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under The Pits and Quarries Control Act, 1971 were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates, or to indicate the presence of buried granular material. These records were used only in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a township base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows: First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot thick layer of sand and gravel, one acre in extent, assuming an average density of 110 pounds per cubic foot.

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 represent only those parts of the deposit lying outside licenced areas (Column 2).

Two successive subtractions are made from the unlicenced area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of favourrable bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated workable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of a workable thickness of 60 feet (18 m) is used. Volume estimates are then multiplied by 3600 (the estimated weight in tons of a one-foot thick section of dolostone, one acre in extent, assuming a bulk density of 165 pounds per cubic foot).

Resources of sandstone are calculated using a bulk density estimate of 146 pounds per cubic foot or approximately 3200 tons per acre. Shale resources are calculated on the basis of a bulk density estimate of 150 pounds per cubic foot.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregates are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975,p.7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

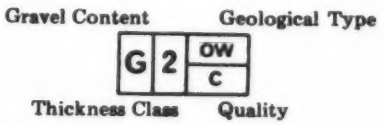
PART II - DATA PRESENTATION AND INTERPRETATION

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources", shows the distribution of bedrock formations, the distribution of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Map 1 is derived directly from the existing surficial geology maps of the area or from air photo interpretation where surficial mapping is incomplete. It shows the extent of sand and gravel deposits within the study area and serves as a base for the calculation of the total sand and gravel resources.

Map 1 presents a summary of all available information related to the quantity and quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbol which identifies each deposit. The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for a given deposit. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess fines may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel. If no information is available, the letters are omitted.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identify the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identify the main quality limitations that may be present in the deposit as discussed in the next section.

The other information presented on Map 1 is designed to give an indication of the present level of extractive activity in the study area. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits are also identified and numbered on Map 1 and described in Table 2.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary, and tertiary. These areas are identified on Map 2 by different shading patterns.

Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by a medium-grey tone on Map 2.

Selected Aggregate Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by a light grey tone on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in a municipality, they may contain large quantities of sand and gravel and should be considered an integral component of the aggregate supply of the municipality.

Areas of tertiary significance are indicated on the map by a dashed line but have no grey tone. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the indicators deal with grain size distribution. The "gravel content", (G or S), indicates the suitability of aggregate for various uses. Deposits containing more than 35 percent crushable gravel are considered to be favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess "fines" or high silt and clay content may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent "oversize" particles (those greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building

aggregate, so must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is "lithology". Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O" or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations. The Engineering Materials Office of the Ontario Ministry of Transportation and Communications has recently compiled a detailed assessment of aggregate suitability for selected areas in southern Ontario. This material has been consulted extensively in preparation of the inventory reports.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of those natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3.

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report but readers are encouraged to discuss them with personnel of the Ontario Ministry of Natural Resources' District Office.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain at roughly the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data

or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, bedrock topography, drift thickness maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources), and from geotechnical well data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the labelled bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of the areas of thin drift are shown by three tones. The darkest tone indicates areas where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas constitute potential resource areas of primary significance due to their easy access. The medium tone indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these also represent potential resource areas. The lightest tone indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive sand and gravel deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the municipality. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, and licenced acreage of the quarry and an estimate of face height. Unlicenced quarries are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics and uses of the bedrock formations found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations of sufficient thickness to support quarry operations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource is usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of bedrock resource areas has been restricted to a single level of significance. Three factors support this approach. Quality and quantity variations are gradual. The areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material. Since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The wider range of possible resource areas allows greater flexibility in locating quarry operations away from areas of intensive land use competition. The Selected Areas are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such a resource area may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN THE TOWNSHIP OF NORTH DUMFRIES

LOCATION AND POPULATION

The Township of North Dumfries occupies an area of 45,888 acres (18 571 ha) flanking the Grand River in the southern portion of the Regional Municipality of Waterloo. The township is shown on the Stratford (40P/7) and Cambridge (40P/8) map sheets of the National Topographic System at a scale of 1:50 000.

The township's total population was 4869 in 1978. In the past five years, the population has increased by only 2 percent (Ontario Ministry of Intergovernmental Affairs 1979; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). The township is characterized by a mix of farming and nonfarming activities, including a large number of rural-residential inhabitants. Unincorporated villages, such as Ayr, Branchton and Roseville provide a limited number of services to the local population.

The adjoining City of Cambridge is a regionally important commercial centre. The total population of the city was 73 314 in 1978; an increase of 13 percent over the 1973 figure (Ontario Ministry of Intergovernmental Affairs 1979; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). The city is experiencing rapid urban and suburban development. This growth, in addition to local development in the township, will result in an increasing demand for mineral aggregates. The township has large resources of good-quality aggregate and is an important regional producer. Care should be taken to ensure the continued availability of as much of the remaining resources as possible.

Access to sand and gravel resources within the township is provided by King's Highways 401, 24, 24A, 97 and 8, by paved regional roads, and by gravel-surfaced township roads. Lines of the Canadian Pacific and Canadian National Railways also cross the township.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography and distribution of unconsolidated sediments, including sand and gravel deposits, are the result of glacial activity that took place in the Late Wisconsinan Substage of the Pleistocene Epoch. This period of time, which lasted from 23 000 to 10 000 years ago, was marked by the repeated advance and melting back of massive, continental ice sheets.

After the maximum glacial advance, approximately 18 000 years ago, the ice front began to recede. Water issuing from the melting ice transported and deposited large amounts of sand and gravel forming a physiographic region known as the Waterloo Hills (Chapman and Putnam 1966, p. 215). This feature occupies parts of the northwest quarter of the township. Varying climatic conditions brought subsequent glacial readvances and retreats from ice masses centred in the Lake Ontario and Lake Erie basins. Each stage left its mark in the topography of North Dumfries. Repeated halts during the eventual retreat of the glacial margins are marked by several hummocky ridges composed of silty till, located in the southwest portion of the township, near Ayr. The western half of the township is predominantly covered by a pitted outwash plain created by meltwater running off the ice margin. These deposits have been worked for sand and gravel for many years and constitute an important regional resource.

Further melting back of the ice margin exposed several kame and esker deposits in the central portion of the township. These deposits are built on the sandy till plain laid down by the previous advance. Major halts in the retreat of the ice margin are marked by the Paris and Galt Moraines on the east side of the Grand River. The moraines form bouldery ridges and are composed for the most part of sandy till (Cowan 1972).

Vast amounts of sand and gravel were deposited in an extensive meltwater channel system which formed in what is now the Grand River valley. These extensively worked deposits also constitute an important resource.

Once the ice had melted back well to the east of the township, meltwater was dammed by the ice margin to form glacial Lake Whittlesey. The lake formed several small beaches and deposited laminated lacustrine silt and clay in the southeast corner of the township, near Branchton. Sand and gravel from these beach deposits have been extracted for local use at several small pits.

EXTRACTIVE ACTIVITY

The Township of North Dumfries has large resources of good-quality aggregates, concentrated in the outwash deposits west of the Grand River. Sand and gravel extraction is a traditional

and important activity in the township. At the time of writing, twenty-five properties were licenced to operate under The Pits and Quarries Control Act, 1971. The licenced properties have a total area of 2030.7 acres (821.8 ha). Using the reserve calculation techniques described in Part I, the total sand and gravel resources still available for extraction in the licenced properties are estimated to be 70 million tons (64 million tonnes).

Annual production figures for licenced pits in the township have been tabulated by the Cambridge District Office of the Ontario Ministry of Natural Resources, since designation of the township in 1971. The average annual production from 1972 to 1978 has been 928,000 tons (841 882 tonnes). Between 1973 and 1978, an additional average annual production of 53,007 tons (48 088 tonnes) came from wayside pits for which permits rather than licences are required.

SELECTED SAND AND GRAVEL RESOURCES

Map 1 shows the widespread occurrence of sand and gravel in the Township of North Dumfries. Much of the western portion of the township is covered by outwash sand and gravel. These materials occupy approximately 25,500 acres (10 300 ha), representing 56 percent of the township's land area. Total sand and gravel resources are estimated to be 1150 million tons (1040 million tonnes). The above figures represent a comprehensive inventory of all granular materials in the township and are not an assessment of the resource base under present economic and technological conditions. Much of the aggregate included in this estimate has low potential for use, either now or in the immediate future.

Of the total resources, six outwash deposits have been selected as areas of primary significance for possible resource protection. These Selected Areas consist of 11,100 acres (4500 ha); approximately 24 percent of the township's land area. The Selected Areas are similar to those identified in an earlier assessment by Cowan (1976).

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1, an outwash terrace at the western boundary of the City of Cambridge, is the largest and best-quality deposit in the Township of North Dumfries. Although the land surface is relatively smooth and level, the presence of kettles, kettle lakes (such as Orrs Lake) and other ice-contact features indicate that the sediments were deposited near a melting ice margin. Such deposits are characterized by considerable textural variations.

The deposit generally consists of 25 to 30 feet (8 to 9 m) of poorly to moderately sorted gravels with 33 percent stone content (Bryant and McLellan 1974). This material overlies considerably finer-grained material which has little potential for crushing.

According to quality data obtained from the Ontario Ministry of Transportation and Communications (M.T.C.), a full range of crushed products, including concrete aggregate, may be produced from the coarse aggregate (Deike 1978). Some selection and sand control may be required in sandy areas and some oversized material exists. Calcite cementation of the gravel occurs in some areas at depths of 15 to 20 feet (5 to 6 m) and may pose extraction problems (Bryant and McLellan 1974). There are eleven licenced properties in the deposit and M.T.C. rating criteria place them in the "moderate to high" category of potential use.

Resource Area 1 occupies 2270 acres (920 ha), exclusive of licenced areas. The population density is low and most of the land is cleared for agriculture. Much of the land flanking Bechtel Creek, Orrs Lake and the wetlands immediately to the east are floodplains and, therefore, environmentally sensitive areas. Available area is thus calculated to be 1900 acres (770 ha). Assuming an average deposit thickness of 20 feet (6 m), estimated sand and gravel resources are 95 million tons (86 million tonnes).

Resource Area 1 is very well situated for extractive development. It is close to the Cambridge and Kitchener-Waterloo markets and road access to the area is excellent, particularly via Highway 401. The potential for rail haulage also exists along the Canadian Pacific Railway, which runs through the southern portion of the deposit.

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Sand and Gravel Resource Area 2 is an outwash terrace, located to the south of Area 1 along the east side of Cedar Creek. The deposit is characterized by irregular topography.

Four pits have been opened in the area; one of which is presently licenced (Pit No. 13). Face heights in the pits vary from 10 to 20 feet (3 to 6 m) and expose moderately sorted and stratified

sand and sandy gravel. The distribution of crushable gravel is variable, but field investigation indicates that it may be as much as 40 to 50 percent in some areas. As in Area 1, the gravel in Area 2 overlies considerably sandier material.

Limited data obtained from the Ontario Ministry of Transportation and Communications give pit use ratings as "low to moderate" (Deike 1978). The main limitations are the variable distribution of the crushable aggregate (which necessitates extensive selection in some areas) and excess fines and clay coatings on gravel particles.

Resource Area 2 consists of 2420 acres (980 ha), exclusive of the licenced area. Cultural constraints are minimal and there has been little previous extraction. The area currently available for extraction is thus calculated to be 2120 acres (860 ha). Assuming an average deposit thickness of 20 feet (6 m), possible resources are estimated to be 105 million tons (95 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 3

Selected Sand and Gravel Resource Area 3 is located in the extreme west. It consists of an outwash terrace, characterized by irregular topography with many stagnant-ice landforms. Bryant and McLellan (1974) state that the terrace may also be till covered in some areas.

Nine pits have been opened in the area; four of which are presently licenced (Pit Nos. 9,10,11 and 12). The four licenced pits are concentrated in the high relief area at the southern end of the deposit. Field examination in Resource Area 3 showed little current activity. Several pit faces expose moderately sorted gravel. Excess fines in the deposit can limit uses. Thickness and quality data are scarce for the northern portion of the deposit.

Resource Area 3 consists of 3500 acres (1420 ha), exclusive of licenced areas. There are relatively few constraints on extraction in the eastern part of the deposit. However, roads, railways and residential development pose significant constraints in the west. Previous extractive activity has been minimal. The area currently available for extraction is thus calculated to be 2850 acres (1150 ha). Assuming an average deposit thickness of 20 feet (6 m), possible sand and gravel resources are estimated to be 140 million tons (127 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 4

Selected Sand and Gravel Resource Area 4 is a buried gravel outwash deposit located to the north of Area 3 in the western portion of the township. There are four pits in the deposit; three are currently licenced for extraction (Pit Nos. 19, 20 and 23). Pit faces range in height from 15 to 25 feet (5 to 8 m) and expose material with a 50 to 75 percent stone content. Data obtained from the Ontario Ministry of Transportation and Communications indicate that sand control is required in sections for the production of Granular Base Course A and 5/8 inch (1.5 cm) crushed gravel. Sand gradings vary from coarse to dirty and blending is required for hot-laid asphaltic products. Some oversize particles are evident, presenting an additional quality constraint.

Area 4 occupies 243 acres (98 ha), exclusive of licenced areas. Cultural constraints are minimal and there has been little previous extraction. The area currently available for extraction is thus calculated to be approximately 195 acres (79 ha). Assuming an average deposit thickness of 20 feet (6 m), total resources are estimated to be 10 million tons (9 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 5

Selected Sand and Gravel Resource Area 5 is an extensive, irregularly shaped outwash deposit, which lies along the west bank of the Grand River, in the south-central portion of the township. The topography of the Area is rolling to hummocky and numerous local depressions or kettles mark the places where glacial ice blocks melted on the outwash plain. The depressions are now filled by marsh deposits. A small esker is also located in the central portion of the deposit, indicating that the outwash was deposited close to the melting ice front. As a result, there is significant textural variation in the deposit and coarse aggregate is not as continuous or as plentiful as would otherwise be expected.

Five sand and gravel pits have been opened in Resource Area 5; three are currently licenced for extraction (Pit Nos. 14, 15 and 21). Face heights in the pits range from 10 to 30 feet (3 to 9 m) and expose variable, often coarse aggregate suitable for road-base and sub-base aggregate and for hot-laid asphaltic sand and stone. The sand fraction grades coarse and dirty and in places is unsuitable for use. Coarse aggregate is located in pockets and lenses and some selection is required for crushing.

Resource Area 5 consists of 2500 acres (1010 ha), exclusive of licenced areas. The area is sparsely populated and there are relatively few physical constraints. Previous extractive activity

has been minimal. The area currently available for extraction is thus calculated to be 2170 acres (880 ha). Assuming an average deposit thickness of 20 feet (6 m), possible sand and gravel resources are estimated to be 110 million tons (100 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 6

Selected Sand and Gravel Resource Area 6 is a small, sandy outwash deposit located to the east of the Grand River. One licenced pit (Pit No. 17) spans the area and extends into a gravel outwash deposit to the west. Face heights average 30 feet (9 m). Material exposed in the gravel deposit has a 55 to 75 percent stone content. Although data for Area 6 is scarce, field investigation indicated that parts of this deposit may contain a higher percentage of sand. The material is acceptable for a number of granular base course and hot-laid asphaltic products.

Area 6 occupies 124 acres (50 ha), exclusive of the licenced area. There has been no previous extractive activity and cultural constraints are minimal. The area currently available for extraction is thus estimated to be 122 acres (49 ha). Assuming an average deposit thickness of 25 feet (8 m), total resources are approximately 8 million tons (7 million tonnes).

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

Four outwash and two ice-contact stratified drift deposits have been selected as Sand and Gravel Deposits of Secondary Significance. Although these deposits are not the "best" resource areas in the township, they should be considered an integral component of the aggregate supply.

The two ice-contact stratified drift deposits are located in the central portion of the township, and consist of isolated areas of irregular, rugged topography. No extractive activity has taken place in the northernmost deposit, but one water well indicates 39 feet (12 m) of gravel. In the southern deposit, one pit is presently licenced for extraction (Pit No. 22). The aggregate in the pit is suitable for a range of road-building products and there are no significant quality constraints. In some parts of these deposits, crushable gravel is variable in occurrence. Field investigation will be required to locate such gravel.

A large deposit of sandy outwash lies on the eastern flank of Selected Sand and Gravel Resource Area 3. Subsurface data and pit exposures indicate that the deposit is fine grained, although some areas of crushable gravel are evident.

No subsurface data are available for the outwash deposits to the southeast of Ayr, or in the central portion of the township. There has also not been any extractive activity in these deposits. In both cases, the secondary deposits are located on the flanks of outwash deposits selected as Sand and Gravel Resource Areas of Primary Significance. It is likely that the aggregate in the secondary deposits is generally similar in quality. The texture of the secondary deposits, however, is probably significantly finer than that of the primary deposits.

An outwash deposit located along the east bank of the Grand River has also been selected at the secondary level. This deposit has seen considerable extractive activity in the past and presently supports two licenced pits (Pit Nos. 16 and 24). Faces in the pits are 10 to 30 feet (3 to 9 m) in height and expose moderately sorted and stratified gravel and sand. Crushed aggregate, including Granular Base Course A, have been produced from all of the pits. The aggregate is also acceptable for hot-laid asphaltic sand and stone. Parts of this outwash deposit are built over, and much of the aggregate is now unavailable for extraction. However, portions of the deposit are still available and protection measures should be considered.

BEDROCK GEOLOGY

The township is underlain by Silurian dolostones and shales of the Guelph and Salina Formations. The units trend northwest and dip gently to the southwest. The bedrock surface is smooth to rolling and its elevation varies from more than 900 feet (274 m) above sea level (a.s.l.) near Orrs Lake to 632 feet (193 m) a.s.l. north of Ayr (Karrow 1963). The north side of a large preglacial valley (now buried under 200 feet (60 m) of drift) passes southeast through the southern portion of the township, near Ayr. Karrow (1963) has shown it as a tributary of the buried Dundas Valley, eroded by a large river which flowed in the area before glaciation.

The thickness of unconsolidated sediments overlying the bedrock surface varies considerably, from areas of little or no drift in the eastern portion of the township and in parts of the Grand River valley, to areas of very thick drift, in some cases over 200 feet (60 m), in the buried preglacial valley. Drift thickness generally ranges from 50 to 150 feet (15 to 46 m) throughout the rest of the township.

The Guelph Formation underlies the eastern three-quarters of the township (Caley 1941; Telford 1979). It consists of massive or thick-bedded, fine-to medium-grained, light brown dolostone. Areas of porous, chemically pure rock are common throughout the unit. Drilling in the area indicates that the Guelph Formation has a minimum thickness of 130 feet (40 m) (Telford 1979). It is quarried for lime at several localities elsewhere in the region, such as Glen Christie and Guelph (Hewitt 1960). It is well suited for lime production due to its high chemical purity. However, the Guelph Formation is generally soft and not resistant to physical weathering processes, rendering the stone unacceptable for production of most road-building or construction aggregates. (Occasionally, it has been crushed for Granular Base Course A). Drift cover over the Guelph Formation generally exceeds 50 feet (15 m), but there are large areas of outcrop and/or thin drift cover in the eastern portion of the township. Extractive development may be feasible in the two areas chosen for possible resource protection. There are also smaller areas of thin drift along the valley of the Grand River (Karrow 1963).

The Guelph Formation is overlain by the Salina Formation in the western portion of the township. The Salina consists of soft grey shale and thin-to medium-bedded dolostone with numerous seams and lenses of gypsum. Drilling indicates that the Salina Formation may be 330 feet (100 m) thick in this area (Telford 1979). Although the Salina Formation is not suitable for production of crushed aggregate, it has economic value as a source of gypsum and is being mined at Hagersville, Caledonia and Drumbo. The Salina Formation is not exposed in the township and drift cover is greater than 50 feet (15 m) throughout the area. Since information on gypsum occurrences in this area is limited, no areas have been selected for possible resource protection.

SELECTED BEDROCK RESOURCE AREAS

Possible bedrock resources in the Township of North Dumfries are located in the Guelph Formation. The dominant use of rock from the Guelph Formation is in the manufacture of lime for the chemical industry. Two Resource Areas have been selected for possible resource protection. Both are located in the southeast corner of the township.

SELECTED BEDROCK RESOURCE AREA 1

Selected Bedrock Resource Area 1 consists of 370 acres (150 ha), located east of Branchton. There is a small surface exposure in the area, but the remainder is covered by thin drift. There has been no extractive activity and cultural constraints are minimal. The area currently available for extraction is thus calculated to be 330 acres (134 ha). Assuming a workable thickness of 60 feet (18 m), possible resources are estimated to be 70 million tons (64 million tonnes).

SELECTED BEDROCK RESOURCE AREA 2

Selected Bedrock Resource Area 2, to the northeast, consists of 1890 acres (760 ha) of outcrop and thinly drift-covered bedrock. Cultural constraints are minimal and there has been no previous extraction. The area currently available for extraction is thus 1660 acres (670 ha). Assuming a workable thickness of 60 feet (18 m), possible resources are estimated to be 360 million tons (330 million tonnes).

SUMMARY

The Township of North Dumfries has possible sand and gravel resources which are regionally important sources of road-building and construction aggregate. Six areas of primary significance have been selected for possible protection. The Selected Resource Areas contain approximately 470 million tons (425 million tonnes) of granular material. Additional resources may be available in several areas of secondary significance. Care should be taken to protect as much of the remaining material as possible for future extractive development.

Possible bedrock resources in the township belong to the Guelph Formation. The stone is suitable for the production of chemical lime. Two Resource Areas have been selected for possible protection, containing total resources of approximately 430 million tons (390 million tonnes).

Enquiries regarding the Aggregate Resources Inventory of the Township of North Dumfries should be directed to the Ontario Ministry of Natural Resources at the Cambridge District Office, Box 2186, Cambridge, Ontario, N3C 2V3 (Tel. (519) 658-9356) or at the Central Region Office, 10670 Yonge Street, Richmond Hill, Ontario, L4C 3C9 (Tel. (416) 884-9203).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, TOWNSHIP OF NORTH DUMFRIES

1 CLASS NO.	2 DEPOSIT TYPE (See Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
1	G-E	110 (44)	8 (7)
	G-IC	900 (365)	50 (45)
	G-K	400 (162)	25 (23)
	G-OW	13,600 (5500)	820 (740)
	S-OW	165 (67)	8 (7)
2	G-E	25 (10)	<1 (<1)
	G-IC	8 (3)	<1 (<1)
	S-IC	2750 (1110)	10 (9)
	G-K	890 (360)	24 (22)
	G-OW	8 (3)	<1 (<1)
	S-OW	5500 (2230)	192 (174)
3	S-IC	35 (14)	<1 (<1)
	G-K	40 (16)	<1 (<1)
	G-LB	4 (2)	<1 (<1)
	G-OW	20 (8)	<1 (<1)
	S-OW	1120 (455)	14 (13)
		25,500 (10 300)	1150 (1040)

N.B. Minor variations in above table are due to rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, TOWNSHIP OF NORTH DUMFRIES

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
LICENCED PITS							
1.	G13-134	K-W Blair Ready Mix	Pt.29	12	121.7 (49.2)	20 (6)	30
2.	G13-216	J-Mar Development	Pt.27, & 28	12	75.0 (30.4)	15-20 (5-6)	30-35
3.	G13-289	Katmos Farm Ltd.	24, 25	12	30.0 (12.1)	10-25 (3-8)	40
4.	–	Forwell Ltd.	24	12	85.9 (34.8)	20 (6)	65
5.	G13-157	Forwell Ltd.	Pt.Lots 20-25	12	573.0 (231.9)	20-30 (6-9)	45-65
6.	G13-272	Gil Pinheiro	Pt.19	11	26.5 (10.7)	15-20 (5-6)	50
7.	G13-92	K-W Blair Ready Mix Ltd.	NW¼ 17 N½ 18	11	129.3 (52.3)	20 (6)	60-80
8.	G13-9	Preston S & G Co. Ltd.	Pt.16 & 17	11	50.0 (20.2)	20 (6)	65
9.	G13-215	Highland Creek Sand & Gravel	Pt.31 & 32	9	232.0 (93.9)	20 (6)	60
10.	–	Festival City Development	Pt.32	9	20.0 (8.1)	20-30 (6-9)	60
11.	–	D. Thomas	Pt.31	9	9.3 (3.8)	35 (11)	60
12.	G13-127	Festival City Development	Pt.32	8	8.8 (3.6)	10 (3)	60
13.	–	Regional Municipality of Waterloo	Pt.25	11	8.5 (3.4)	10-15 (3-5)	50
14.	–	G.E. Parkinson	Pt.15 & 16	8	140.0 (56.7)	30 (9)	35
15.	–	Vera M. Cowan	Pt.1 & 2	8 W.G.R.	18.5 (7.5)	12 (4)	50

TABLE 2 | SAND AND GRAVEL PITS, TOWNSHIP OF NORTH DUMFRIES

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
16.	G13-243	Waynco Ltd.	Pt.1, 2 & 3	7 E.G.R.	86.0 (34.8)	20 (6)	80
17.	G13-291	Waynco Ltd.	Pt. of Sub-division L.1	9 E.G.R.	100.0 (40.5)	30 (9)	55-75
18.	–	J.A. Hahn	N½ 36	12	9.3 (3.8)	15 (5)	0-5
19.	G13-182	G.Morley Snyder	Pt.32	11	11.2 (4.5)	15 (5)	60
20.	–	Cedar CR Developments Inc.	Pt.31	11	38.3 (15.5)	15 (5)	70
21.	–	341595 Ontario Ltd.	Pt.21 & 22	7	45.4 (18.4)	10-15 (3-5)	45
22.	–	385415 Ontario Ltd.	N½ 26	8	43.0 (17.4)	not open	
23.	–	G. Morley Snyder	Pt.32	11	20.0 (8.1)	20 (6)	60
24.	–	Waynco Ltd.	Pt.1 & 2	7 E.G.R.	74.0 (30.0)	not open	
25.	–	K-W Blair Ready Mix Ltd.	Pt.16	11	75.0 (30.4)	not open	
					2030.7 (821.8)		
UNLICENCED PITS							
26.	G13-179	George Sandilands	18	11	–	25-35 (8-11)	65
27.	G13-204	Werner Brothers	33, 34	9	–	12 (4)	35-75
28.	G13-222	Gordon Marshall	34 & 35	9	–	12 (4)	low
29.	G13-205	O.J.O.	36	10	–	15 (5)	low

TABLE 2 | SAND AND GRAVEL PITS, TOWNSHIP OF NORTH DUMFRIES

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
30.	G13-144	Staeger	35	10	–	15 (5)	20-50
31.	G13-143	N. Shantz	34	10	–	15 (5)	25
32.	G13-148	J.O. Moore No. 1	25-26	10	–	–	30
33.	G13-149	Ernest Sage	25	10	–	20 (6)	15
34.	G13-209	Kitchener-Police Association	25-26	11	–	10 (3)	Variable
35.	G13-184	M.T. Milroy	16	9 & 10	–	–	60-80
36.	G13-278	Findlater Bros.	22	7	–	40 (12)	20
37.	G13-277	Rutherford	20 & 21	7	–	20 (6)	35
38.	G13-244	Glaud Marcus	1	7 E.G.R.	–	30 (9)	30-80
39.	G13-242	McQuay	3	7 E.G.R.	–	10 (3)	35-60
40	G13-241	Shantz Farms	1	8 E.G.R.	–	10-15 (3-5)	–
41.	–	Marathon Realty	36	9	–	15-20 (5-6)	60
42.	G13-80	J.D. Moore No. 2	24	10	–	20 (6)	40
43.	G13-138	A. Young	17, 18	10	–	25 (8)	50
44.	G13-206	M.T.C.	31	10	–	10-30 (3-9)	10-40

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, TOWNSHIP OF NORTH DUMFRIES

1 DEPOSIT NO.	2 UNLICENCED AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
1.	2270 (920)	365 (148)	5 (2)	1900 (770)	20 (6)	95 (86)
2.	2420 (980)	285 (115)	10 (4)	2120 (860)	20 (6)	105 (95)
3.	3500 (1420)	640 (260)	25 (10)	2850 (1150)	20 (6)	140 (127)
4.	243 (98)	45 (18)	3 (1)	195 (79)	20 (6)	10 (9)
5.	2500 (1010)	320 (130)	10 (4)	2170 (880)	20 (6)	110 (100)
6.	124 (50)	2 (1)	0 (0)	122 (49)	25 (8)	8 (7)
	11,100 (4500)	1660 (670)	53 (21)	9400 (3800)		470 (425)

N.B. Minor variations in above table are due to rounding of data.

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, TOWNSHIP OF NORTH DUMFRIES

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **WORKABLE THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
0-3 (0-1)	Guelph	60 (18)	800 (325)	175 (159)
3-25 (1-8)	Guelph	60 (18)	1770 (720)	380 (345)
25-50 (8-15)	Guelph	60 (18)	1680 (680)	360 (325)
			4250 (1720)	910 (830)

N.B. Minor variations in above table are due to rounding of data.

TABLE 5 | QUARRIES, TOWNSHIP OF NORTH DUMFRIES

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)
			NONE			

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, TOWNSHIP OF NORTH DUMFRIES

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 UNLICENCED AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	8 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
1	0-25 (0-8)	370 (150)	40 (16)	0 (0)	330 (134)	60 (18)	70 (64)
2	0-25 (0-8)	1890 (760)	230 (93)	0 (0)	1660 (670)	60 (18)	360 (330)
		2260 (920)	270 (109)	0 (0)	1990 (800)		430 (390)

N.B. Minor variations in above table are due to rounding of data.

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APPENDIX B-GLOSSARY

ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

CAMBRIAN

The first Period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago; the Cambrian precedes the Ordovician Period.

CLAST

An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone, and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DEVONIAN

A Period of the geological past thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

DIRT

See fines.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No.200 mesh screen (0.074 mm). Also described informally as "dirt", these particles are in the silt- and clay-size range.

GLACIAL LOBE

A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced and retreated numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

GRADATION

The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder		>-256 mm
Gravel	cobble	64-256 mm
Gravel	pebble	4-64 mm
Gravel	granule	2-4 mm
Sand	coarse	.5-2 mm
	medium	.25-.5 mm
	fine	.074-.25 mm
Silt, clay		<.074 mm

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability, and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

H.L. (HOT-LAID OR ASPHALTIC AGGREGATE)

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3, and 4), or as binder course (H.L. 2, 6, and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition, and grain size. Generally, the description of the physical character of a rock.

MELTWATER CHANNEL

A drainage way, usually terraced, produced by water flowing away from a melting glacier margin.

ORDOVICIAN

An early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

PALEOZOIC ERA

One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago. The Paleozoic Era (or Ancient Life Era) is subdivided into six geologic Periods, of which only four (Cambrian, Ordovician, Silurian, and Devonian) can be recognized in southern Ontario.

PLEISTOCENE

An Epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity.

POSSIBLE RESOURCE

Estimates of mineral aggregate material based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt, or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone, and mudstone.

SILURAIN

An early Period of the Paleozoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial stage of the Pleistocene Epoch in North America. It began approximately 85,000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX C-GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 7000 to 85 000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and they can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley, The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain-size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and cross-bedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good-quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt-and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. They vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout southern Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and grain-size variability. They are given a qualitative

rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. They occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain-size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are no large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the underlying material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAIN (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. They commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best resource areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN FORMS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from,

and deposited on , pre-existing lacustrine sand plain deposits. Windblown sediments are almost invariably composed of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

APPENDIX D-GEOLOGY OF BEDROCK DEPOSITS

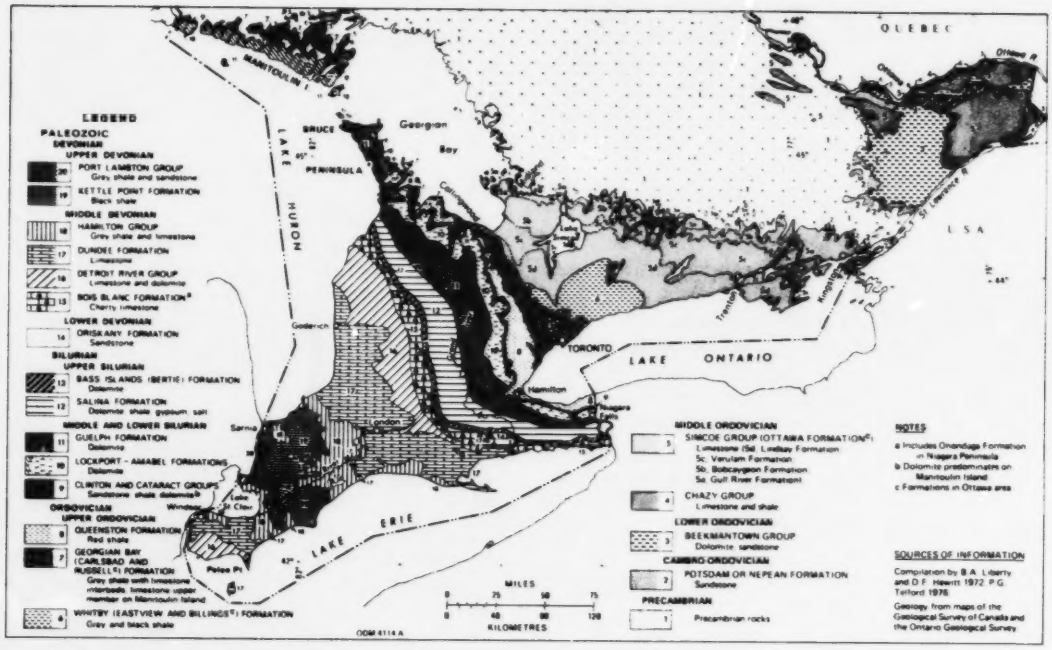


Figure 2 - Bedrock Geology of Southern Ontario

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

BASS ISLANDS FORMATION (UPPER SILURIAN)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11-18m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate due to high soundness losses.

BOBCAYGEON FORMATION (MIDDLE ORDOVICIAN)

Composition: Compact, homogeneous, medium- to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

BOIS BLANC FORMATION (LOWER-MIDDLE DEVONIAN)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High chert content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion

Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

DUNDEE FORMATION (MIDDLE DEVONIAN)

Composition: Fine- to medium-crystalline, brown ish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone. Used at St. Marys for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

GULL RIVER FORMATION (MIDDLE ORDOVICIAN)

Composition: Member A: thin-to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield, Victoria County, and Uthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

LOCKPORT AND AMABEL FORMATIONS (MIDDLE SILURIAN)

Composition: Amabel Formation (Georgetown to the Bruce Peninsula): massive, fine crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Georgetown to Niagara Falls): thin- to massive-bedded, fine- to medium-grained dolostone. Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, and building stone throughout their area of occurrence, and are a valuable aggregate resource. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

ONONDAGA FORMATION (MIDDLE DEVONIAN)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliffe Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey brown, fine-grained, very cherty limestone having an estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High chert content makes much of the material unsuitable for concrete aggregate.

OTTAWA FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of lime for cement production and agricultural uses.

OXFORD FORMATION (LOWER ORDOVICIAN)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES.

DETROIT RIVER GROUP (MIDDLE DEVONIAN)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change). Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important

source of high purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces 80% of Ontario's cement. Its dolomitic reefal facies is also important for lime production to the north. It is generally unsuitable for crushed stone. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for crushed stone.

GRENVILLE MARBLE (PRECAMBRIAN)

Composition: Recrystallized white limestone and dolostone, fine- to coarse-grained, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazo chips, poultry grit, decorative stone, and building stone.

GUELPH FORMATION (MIDDLE SILURIAN)

Composition: Aphanitic- to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. The Guelph Formation and the underlying Amabel Formation have a combined thickness of 200 feet (61 m) on the Niagara Peninsula and more than 400 feet (122 m) on the Bruce Peninsula. Uses: The main use is for dolomitic lime in the construction industry. It is quarried at Glen Christie and Guelph.

LINDSAY FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Member: fine-crystalline, rubbly, nodular, weathering limestone. Upper Member: grey calcareous claystone with shaly partings and bioclastic layers. The rock is "soft" and weathers to rubble. Both members are characterized by low dolomite content and by numerous clayey partings. Uses: Quarried at Picton, Ogden Point, Colborne, and Bowmanville for lime. It is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

VERULAM FORMATION (MIDDLE ORDOVICIAN)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200-300 feet (61-91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for lime. It is unsuitable for crushed stone due to clay impurities and many clayey interbeds, low abrasion resistance, high soundness losses and poor freeze-thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

GEORGIAN BAY FORMATION (UPPER ORDOVICIAN)

(Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas). Composition: Soft, fissile, blue grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Five producers in Metro Toronto and Cooksville produce brick and structural tile (Guillet 1967). Lightweight aggregate is also produced at Streetsville by heat expansion of the shale.

HAMILTON GROUP (MIDDLE DEVONIAN)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The Group has six formations. Only the Arkona is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile and brick.

QUEENSTON FORMATION (UPPER ORDOVICIAN)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are 12 large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa (Guillet 1967). All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

NEPEAN (POTSDAM) FORMATION (CAMBRO-ORDOVICIAN)

Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

SALINA FORMATION (UPPER SILURIAN)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum. The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amhertsburg, Windsor, and Sarnia.

WHITBY FORMATION (UPPER ORDOVICIAN)

(Formerly known as Collingwood Shale near Toronto). Composition: Brown to black fissile shale. Uses: Quarried at Bowmanville for use in cement production. Testing indicates that the Whitby Formation may produce satisfactory lightweight expanded aggregate.

DEPOSIT SYMBOL

Deposits are identified by gravel content, thickness class, deposit type and quality indicators. Gravel content is expressed as percentage of crushable material. Classes are based on potential aggregate tonnage per acre and are designated numerically. Type refers to geologic origin. Quality modifiers indicate variations in grain size distribution and lithology.

Gravel Content	Thickness Class	Geological Type
		Quality Indicators

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.
?	Requires investigation.

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 18 500)
2	10-20 (3-6)	25,000-50,000 (9 000-18 500)
3	5-10 (1.5-3)	12,500-25,000 (4 500-9 000)
4	less than 5 (< 1.5)	less than 12,500 (< 4 500)

Geological Type

IC	Undifferentiated Ice-Contact Stratified Drift	OW	Outwash
ICT	Ice-Contact Terrace	LB	Lacustrine Beach
K	Kame	LP	Lacustrine Plain
E	Esker	LD	Lacustrine Delta
EM	End Moraine	AL	Older Alluvium
		WD	Windblown Forms

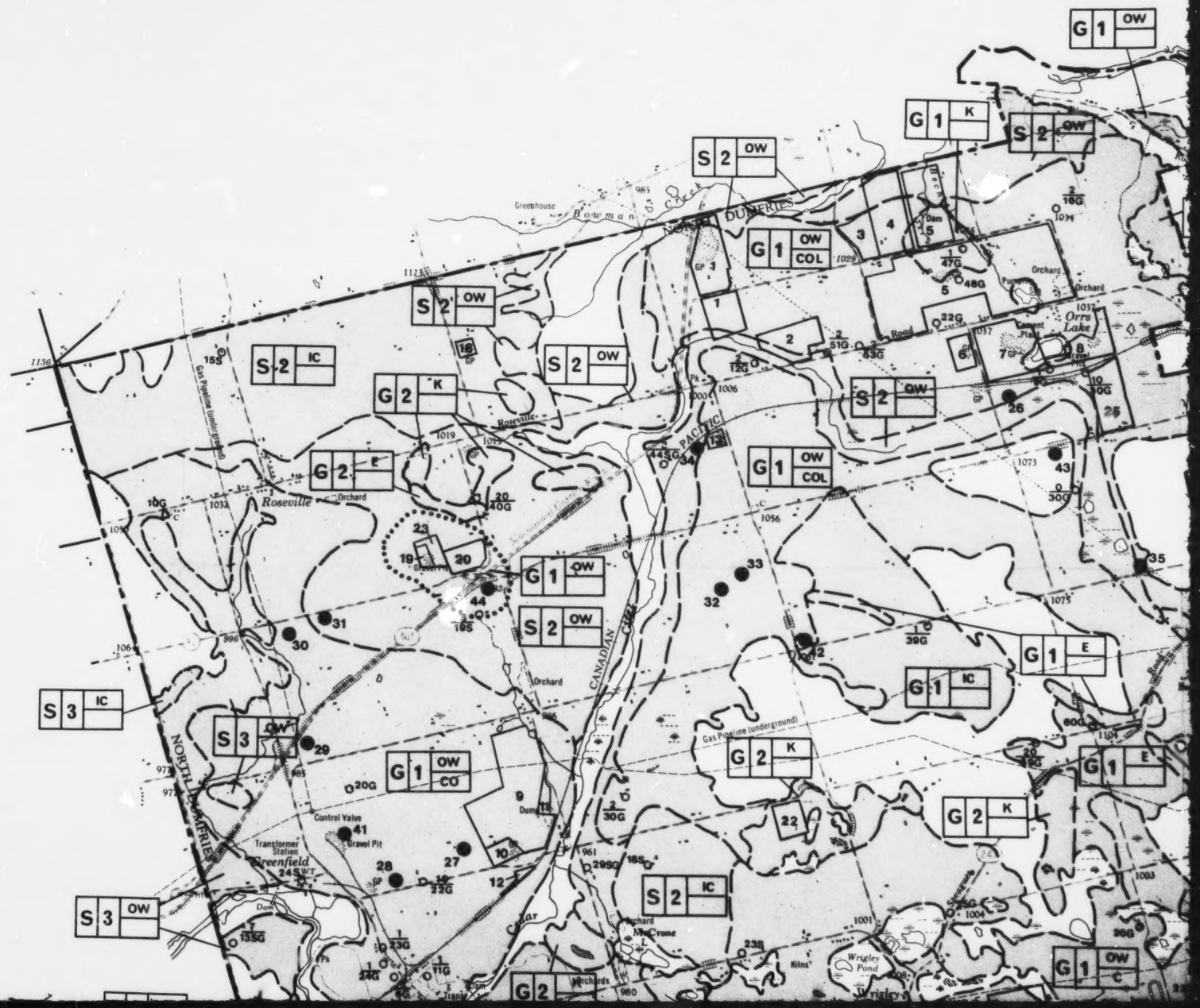
(see Appendix C for descriptions of Geological Types.)

Quality Indicators

	If blank, no known limitations present
C	Clay and/or silt (fines) present in objectionable quantities
L	Deleterious lithologies present
O	Oversize particles or fragments present in objectionable quantities

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Selected drilling data from the Ontario Ministry of the Environment and the Petroleum Resources Section, Ontario Ministry of Natural



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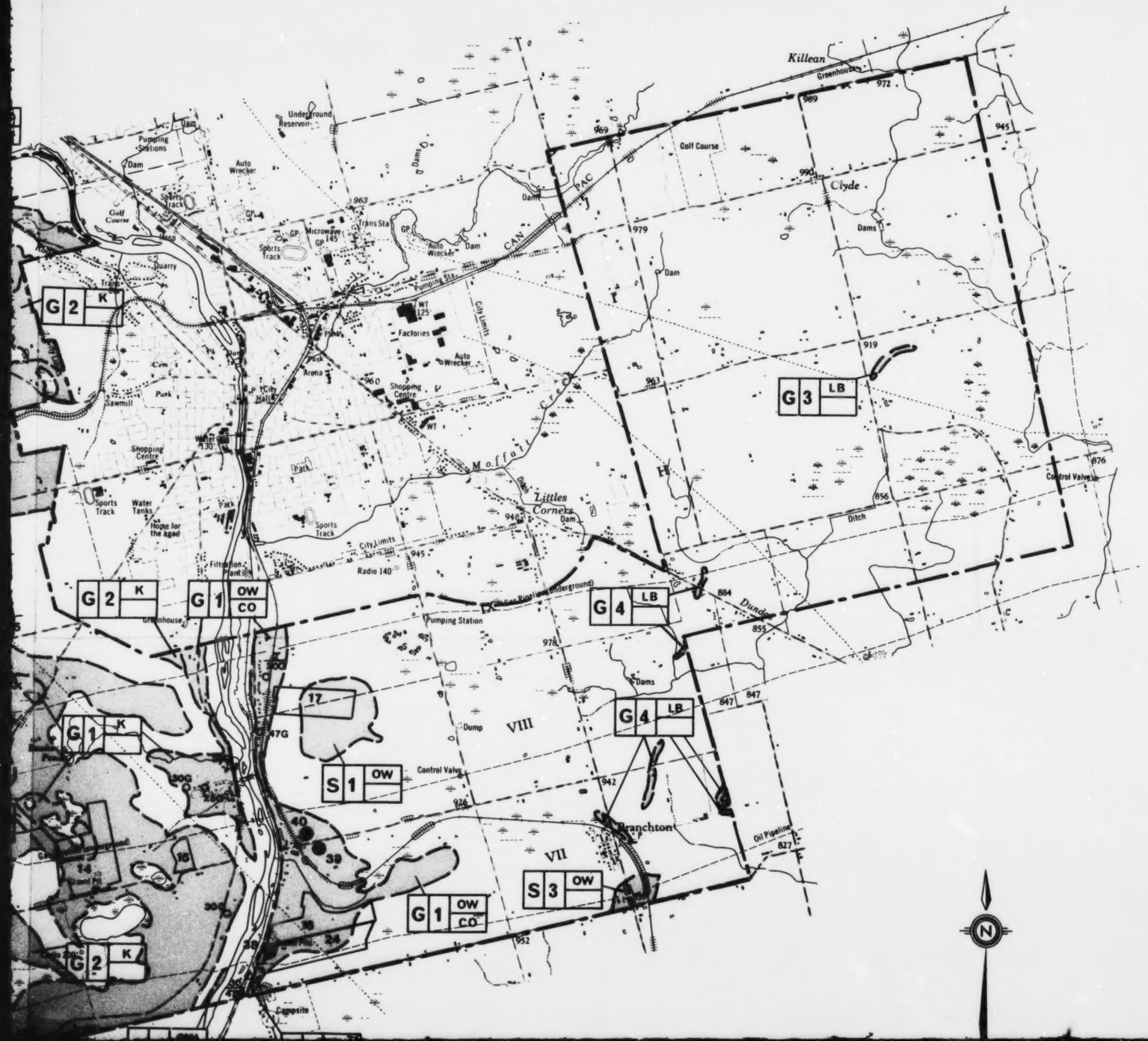
G 3 LB
G 4 LB
Killean
Clyde
Roseville
Branchton
Littles Corners
Bowman Creek
Orrs Lake
Wrigley Pond
Golf Course
Greenhouse
Orchard
Gravel Pit
Sawmill
Factories
Shopping Centre
Auto Wrecker
Sports Track
Pumping Station
Underground Reservoir
Gas Pipeline (underground)
Oil Pipeline
Control Valve
Dump
Ditch
Dams
Quarry
Arena
City Limits
Filtration Plant
Home for the Aged
Transformer Station
Microwave
Trans Sta
Water Tanks
Campsite
CANADIAN PACIFIC
DUNDAS
Moffat Creek
Mill Creek
N



Ministry of Natural Resources

Ontario

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Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

THE TOWNSHIP OF NORTH DUMFRIES

REGIONAL MUNICIPALITY OF WATERLOO

MAP 1

DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale: 1:50,000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 40 P/8, 40 P/7

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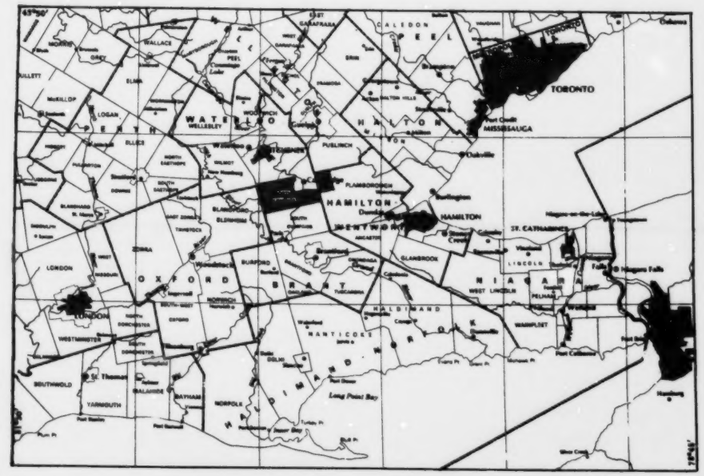

SYMBOLS

(Some symbols may not apply to this map)

- Geological and aggregate thickness boundary. Shading indicates deposit area.
- S 1 K CLO — Deposit symbol
- 3 — Licenced property boundary; Property number: see Table 2.
- 4 — Unlicenced sand or gravel pit; Property number: see Table 2.
- Selected drilling location indicating thickness of overburden

S	Less than 35% gravel.
?	Requires investigation.

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 18 500)
2	10-20 (3-6)	25,000-50,000 (9 000-18 500)
3	5-10 (1.5-3)	12,500-25,000 (4 500-9 000)
4	less than 5 (< 1.5)	less than 12,500 (< 4 500)

Geological Type

IC	Undifferentiated Ice-Contact Stratified Drift	OW	Outwash
ICT	Ice-Contact Terrace	LB	Lacustrine Beach
K	Kame	LP	Lacustrine Plain
E	Esker	LD	Lacustrine Delta
EM	End Moraine	AL	Older Alluvium
		WD	Windblown Forms

(see Appendix C for descriptions of Geological Types.)

Quality Indicators

	If blank, no known limitations present
C	Clay and/or silt (fines) present in objectionable quantities
L	Deleterious lithologies present
O	Oversize particles or fragments present in objectionable quantities

SOURCES OF INFORMATION

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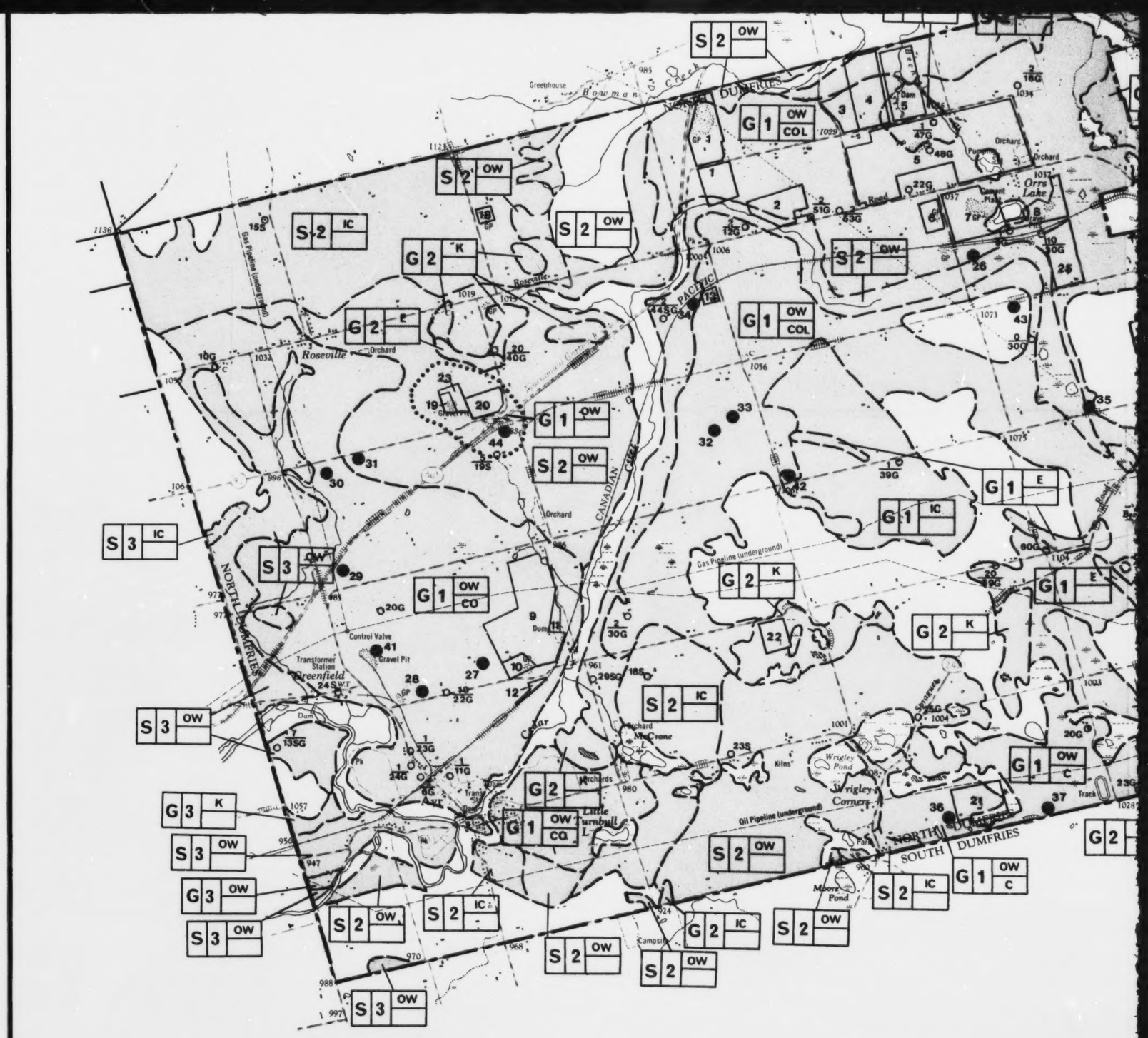
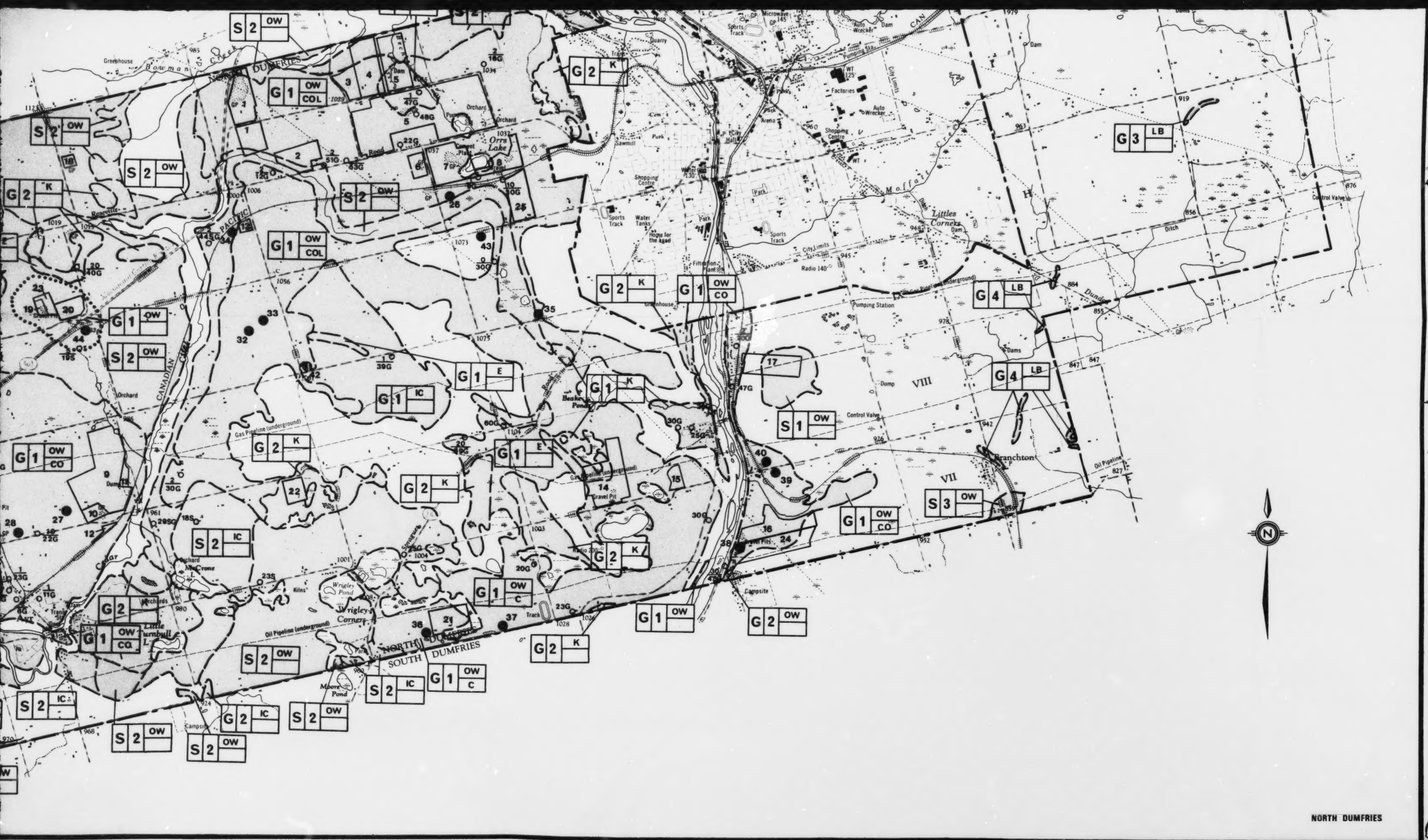
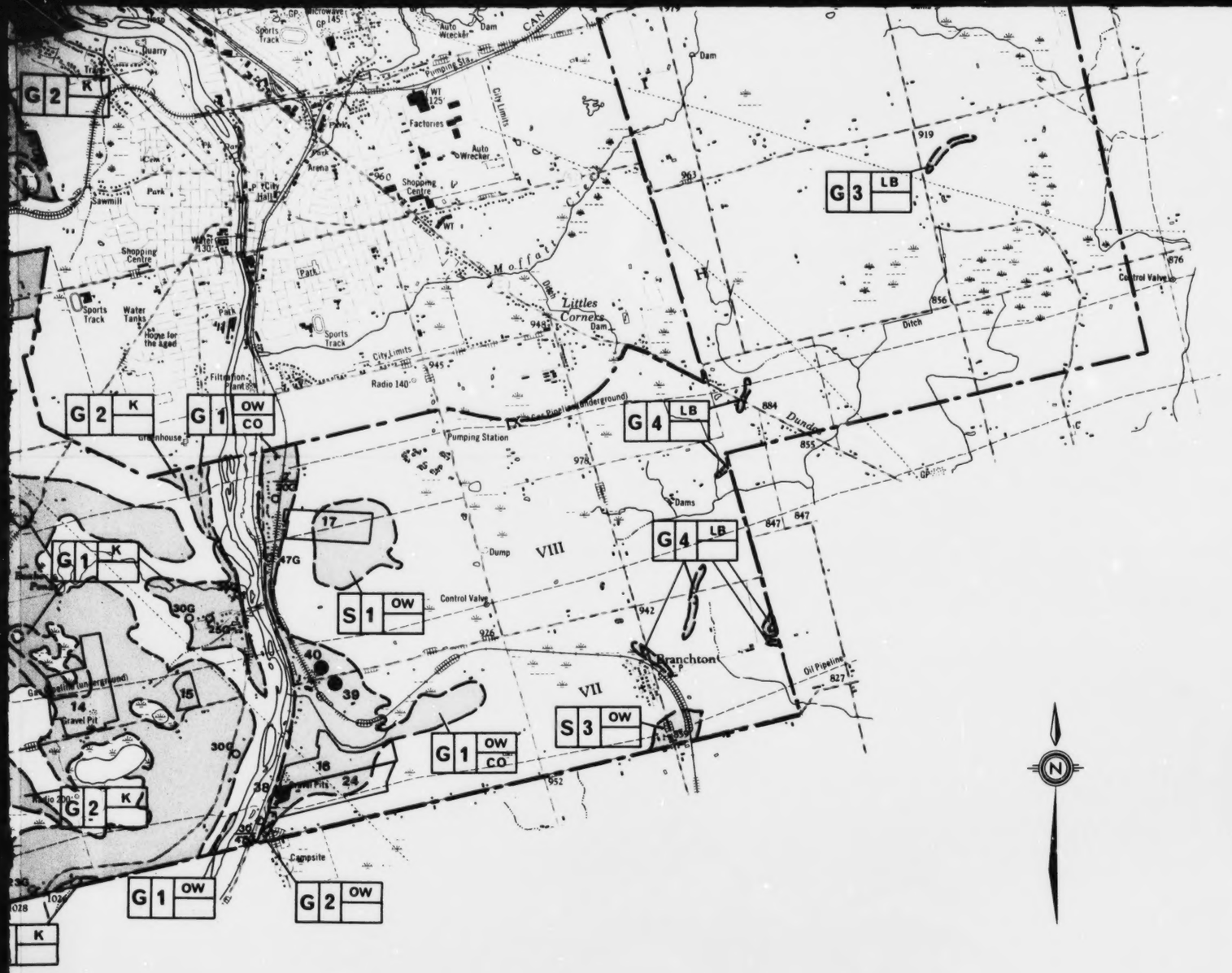




NORTH DUMFRIES



NORTH DUMFRIES

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DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

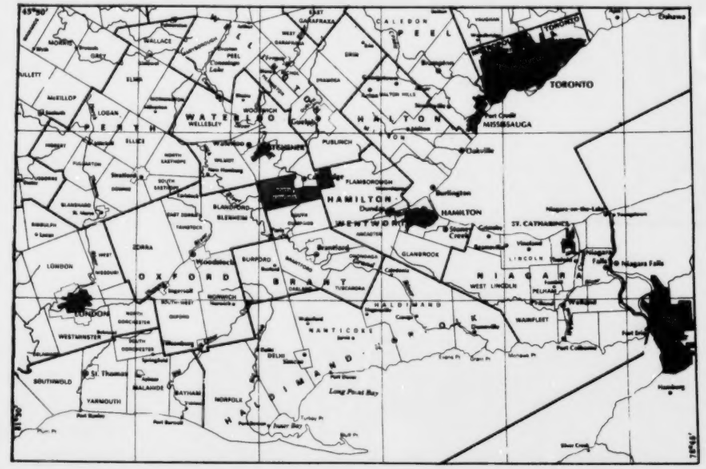
Scale: 1:50,000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 40 P/8, 40 P/7

© OMNR-OGS 1980



SYMBOLS

(Some symbols may not apply to this map)

- Geological and aggregate thickness boundary. Shading indicates deposit area.
- S 1 | IC / CLO — Deposit symbol
- 3 — Licenced property boundary; Property number: see Table 2.
- 4 — Unlicenced sand or gravel pit; Property number: see Table 2.
- 6/23 — Selected drilling location indicating thickness of overburden overlying reported thickness of granular materials (in feet) (Note: S-sand, G-gravel, C-clay, T-till)
- Buried deposit boundary. Shading indicates deposit area.

DUMFRIES
Bowman's Creek
Greenhouse
Dam
Pumping Stations
Underground Reservoir
Auto Wrecker
Golf Course
Sports Track
Quarry
Trans Sta
Microwave
Grave
Orchard
Pumping Sta
Factories
Arena
City Hall
Park
Sawmill
Shopping Centre
Water Tanks
Home for the aged
Littles Corners
City Limits
Radio 140
Radio 200
Fittleton Plant
Greenhouse
Pumping Station
Dump
Control Valve
Branchton
Gravel Pits
Campsite
Gas Pipeline (underground)
CANADIAN
PACIFIC
Rosentte
Orchard
McCrone
Wrigley Pond
Kilns
Ditch
Spruces
Cem
Rd
Trail
Gravel
Underground
Microwave
Trans Sta
Auto Wrecker
Sports Track
Golf Course
Water Tanks
Shopping Centre
Pumping Sta
Factories
Arena
City Hall
Park
Sawmill
Quarry
Grave
Dump
Control Valve
Pumping Station
Gravel Pit
Gravel Pits
Campsite
Home for the aged
Fittleton Plant
Greenhouse
Golf Course
Sports Track
Radio 140
Radio 200
City Limits
Underground
Dams
Dam
Ditch
Spruces
Kilns
Wrigley Pond
Orchard
McCrone
Rosentte
Gas Pipeline (underground)
CANADIAN
PACIFIC
Bowman's Creek
DUMFRIES
Greenhouse
Branchton
Littles Corners
Mofat
Park

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Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

THE TOWNSHIP OF NORTH DUMFRIES

REGIONAL MUNICIPALITY OF WATERLOO

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale: 1:50,000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 40 P/8, 40 P/7

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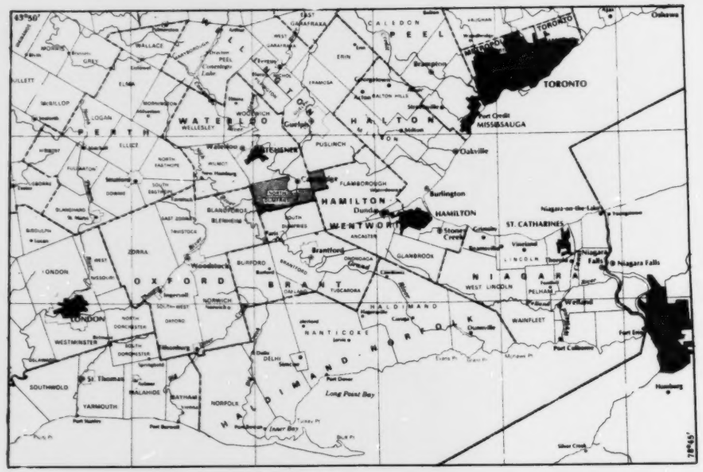

SYMBOLS
(Some symbols may not apply to this map)

- Geological and aggregate thickness boundary.
- Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.
- Selected sand and gravel resource area; Tertiary significance.
- 2 — Licenced property boundary; Property number: see Table 2.
- 4 — Unlicenced sand or gravel pit; Property number: see Table 2.
- Buried deposit boundary.

SOUTH DUMFRIES

Orchard
CANADIAN
Gas Pipeline (underground)
Ditch
Dump
VIII
Control Valve
Dams
Branchto
VII
Gravel Pit
Gravel Pits
Radio 200
Campsite
Orchard
McCrone L.
Orchards
Kilns
Wrigley Pond
Wrigley Corners
Sprucrest
Little Turnbull L.
Oil Pipeline (underground)
Moore Pond
Park
Dam
Campsite
31
42
9
10
22
14
15
17
40
39
16
24
38
21
1064
996
977
961
1003
1004
1001
1028
1026
980
1057
956
947
960
924
970
968
988
997
942
926
952

SYMBOLS

(Some symbols may not apply to this map)

- Geological and aggregate thickness boundary.
- Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.
- Selected sand and gravel resource area; Tertiary significance.
- Licenced property boundary; Property number: see Table 2.
- Unlicenced sand or gravel pit; Property number: see Table 2.
- Buried deposit boundary.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
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This map is to accompany O.G.S. Aggregate Resources Inventory Paper 14.

NORTH DUMFRIES

NORTH DUMFRIES
SALINA FORMATION
GUELPH FORMATION
Roseville
Greenfield
Bowman
Beckhill
Orrs Lake
Cedar
Spruce
Beake Pond
Wrigley Pond
McCrone
Greenhouse
Cement Plant
Gravel Pit
Gravel Pits
Orchard
Orchards
Kilns
Dump
Dam
Quarry
Factories
Arena
Park
Golf Course
Sports Track
Water Tanks
Home for the Aged
Shopping Centre
Auto Wrecker
Sawmill
Pumping Station
Underground Reservoir
Control Valve
Transformer Station
Gas Pipeline (underground)
Radio 140°
Radio 200°
City Limits
Roseville
PACIFIC
CANADIAN
Road
Creek

THE T

PALEOZ
SI

SY
(Some symbols may

Geological boundary.

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ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

THE TOWNSHIP OF NORTH DUMFRIES

REGIONAL MUNICIPALITY OF WATERLOO

MAP 3
BEDROCK RESOURCES

Scale: 1:50,000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: **40 P/8, 40 P/7**

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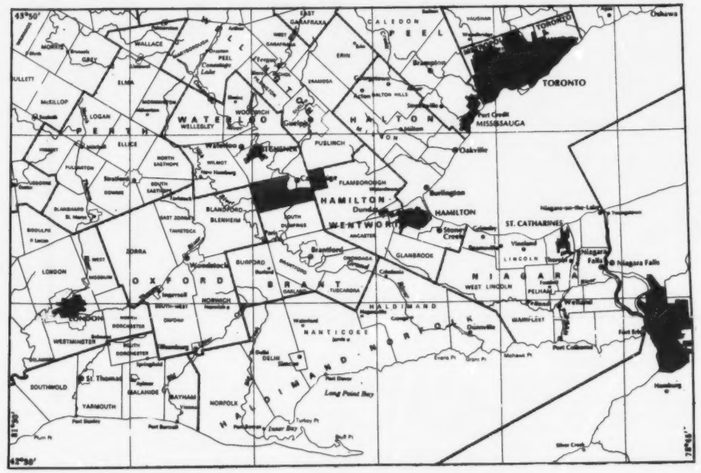


LEGEND

PALEOZOIC

SILURIAN

UPPER SILURIAN

SALINA FORMATION
Dolostone shale, gypsum, salt

MIDDLE AND LOWER SILURIAN

GUELPH FORMATION
Dolostone

SYMBOLS

(Some symbols may not apply to this map)

Geological boundary.

25 Drift thickness contour line (25 foot (8 m) interval).

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

NORTH DUMFRIES
Bowman Creek
Greenhouse
Dam
Beckhel Crk
Quarry
Trans Sta
Grave
City Limits
Microwave
Sports Track
Auto Wrecker
Pumping Sta
Factories
Cem
Arena
Shopping Centre
City Hall
Sawmill
Park
Water Tank
Orrs Lake
Cement Plant
Gravel Pits
Orchard
Road
Roseville
PACIFIC
Gas Pipeline (underground)
Golf Course
Water Tanks
Home for the aged
Sports Track
Filtration Plant
Radio 140
Pumping Station
Dump
Control Valve
Beake Pond
Gravel Pit
Campsite
Radio 200
Transformer Station
Greenfield
SALINA FORMATION
GUELPH FORMATION
Cedar
Ayr
Trans Sta
Little Turnbull L
Orchard
McCrone L
Kilns
Wrigley Pond
Wrigley Corners
Oil Pipeline (underground)
Park
Moore Pond
Track
Ditch
Springers
NORTH DUMFRIES
SOUTH DUMFRIES

BEDROCK

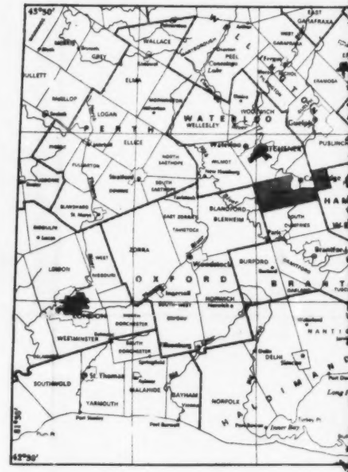
Scale: 1:

Mile 1

Metres 1000

NTS Reference: 40

© OMNR-OGS 1980



GUELPH FORMATION

NORTH DUMFRIES

LE

PALEOZOIC

SILURIAN

UPPER SILURIAN

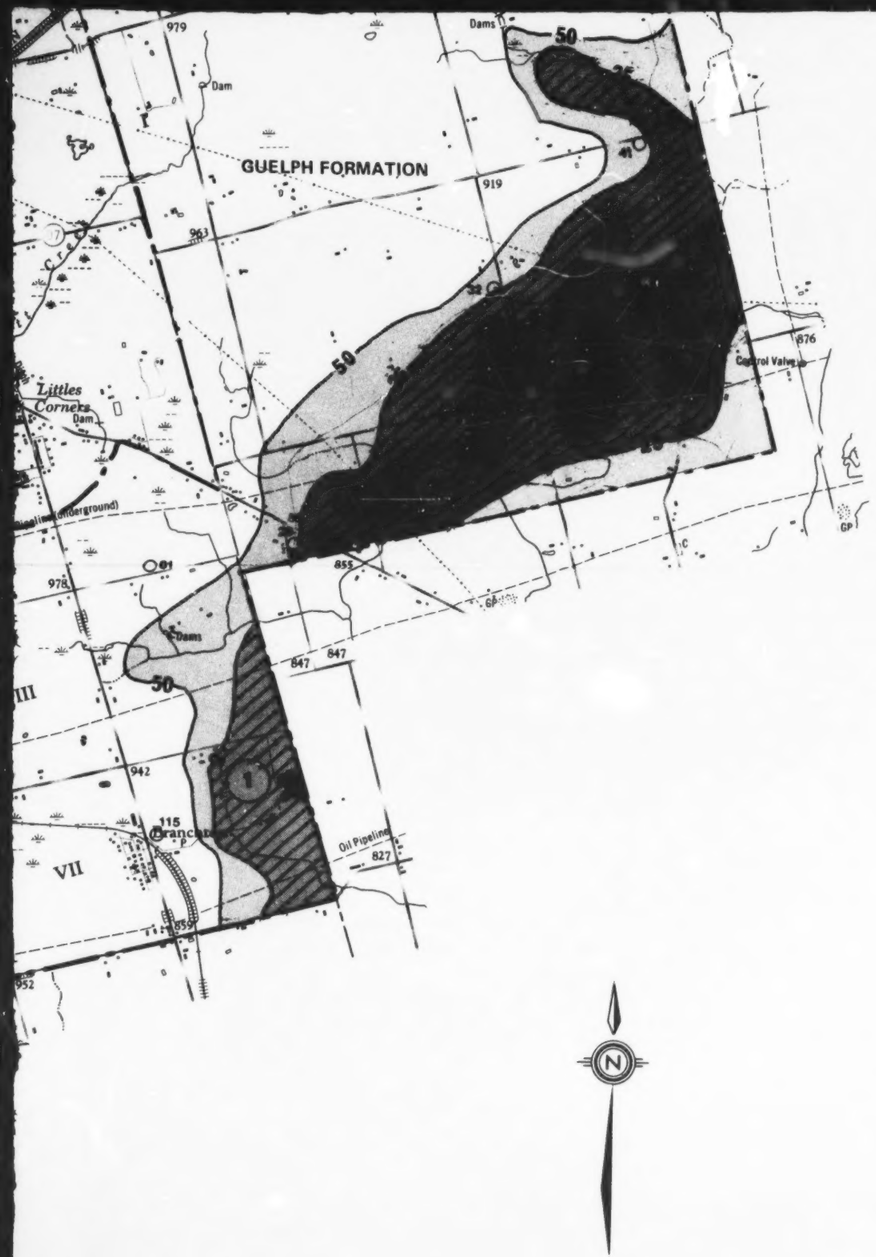
SALINA FORMATION

Dolostone shale, gypsu
salt

SYMBOLS

(Some symbols may not apply to this map)

- Geological boundary.
- 25 — Drift thickness contour line (25 foot (8 m) interval).
- x — Isolated bedrock outcrop.
- Bedrock within 3 feet (1 m) of surface: see Table 4.
- Bedrock covered by 3 to 25 feet (1 m to 8 m) of overburden: see Table 4.
- Bedrock covered by 25 to 50 feet (8 m to 15 m) of overbu den: see Table 4.
- 1 — Selected bedrock resource area; Deposit number: see Table
- Q3 — Licenced property boundary; Property number: see Table
- Q4 — Quarry property number: see Table 5.
- 27 — Selected drilling location indicating reported depth to bedro (in feet).



NORTH DUMFRIES

BEDROCK RESOURCES

Scale: 1:50,000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: **40 P/8, 40 P/7**

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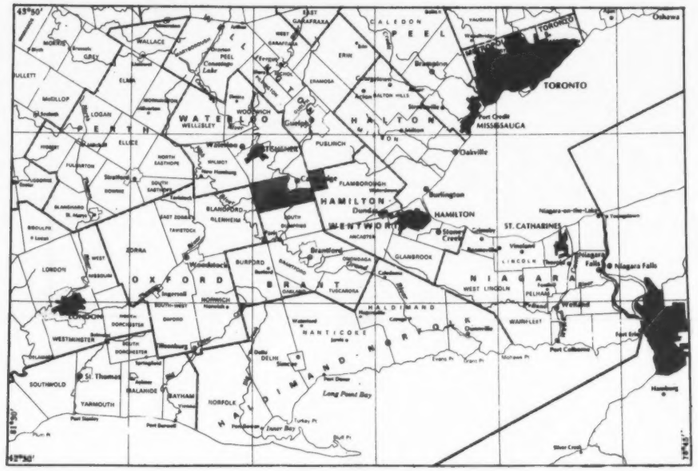

LEGEND

PALEOZOIC

SILURIAN

UPPER SILURIAN

SALINA FORMATION
Dolostone shale, gypsum, salt

MIDDLE AND LOWER SILURIAN

GUELPH FORMATION
Dolostone

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